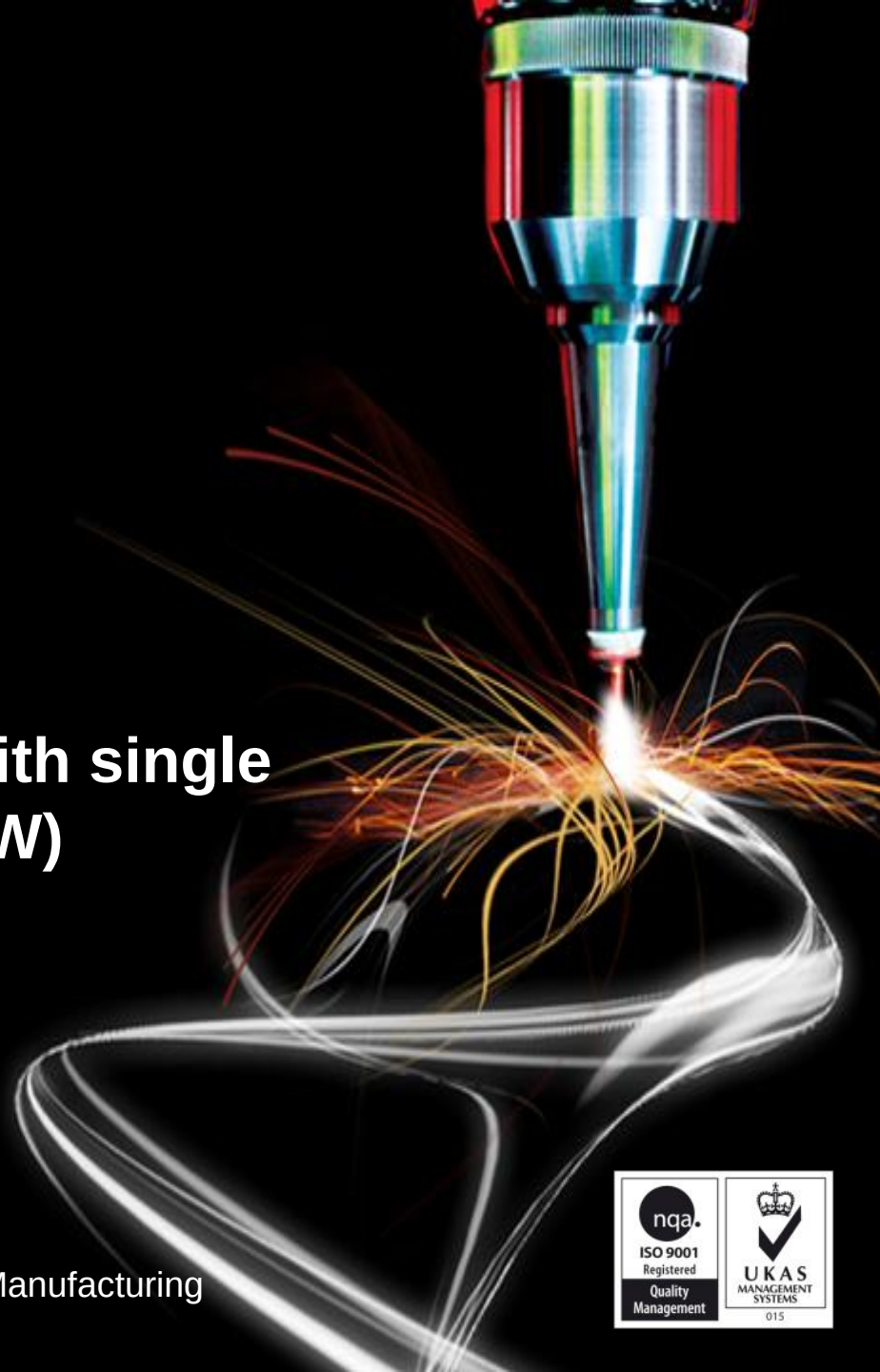
SPI® Lasers

Opening new possibilities with single mode oscillation welding (CW)

March 2018



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Agenda

- Introduction
- What is oscillation welding?
- Comparison to conventional laser welding
- Weld width controllability
- Examples:
  - Stainless Steel welding
  - Aluminium Welding
  - Copper Welding
- Summary

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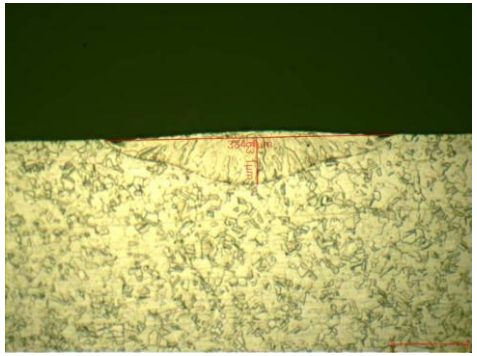
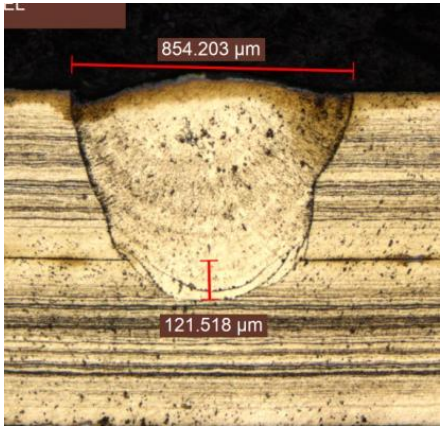
Introduction

- With traditional fixed-head welding:
  - conduction limited
  - keyhole
- With Oscillation Welding it's possible to control the weld so that there is more flexibility.



CONDUCTION LIMITED WELD

KEY HOLE WELD



OSCILLATION WELD

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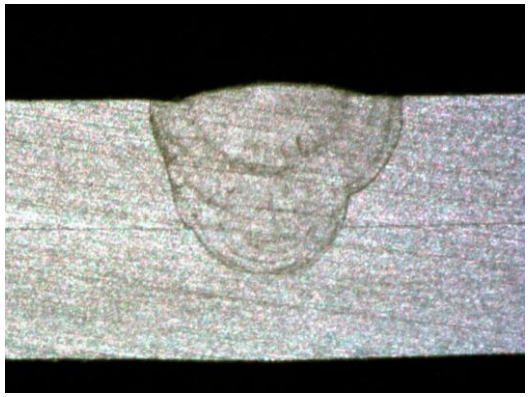
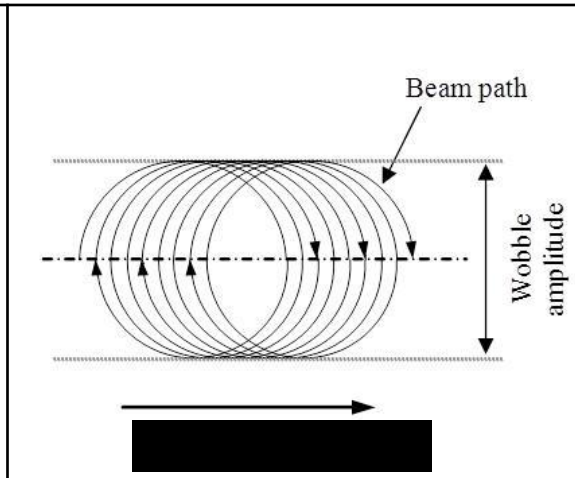
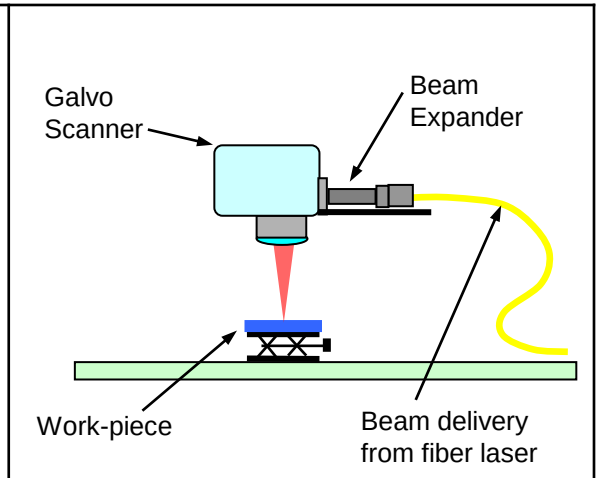
What is Oscillation Welding?

- Rapidly rotate beam to create weld shape
- Uses a single mode laser
- Uses a small focal spot
- Uses a galvo scanner
- Can use longer FL scan lens







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Comparison to Conventional Laser Welding

Fixed-Head Welding	Oscillation Welding
Uses large focal spot sizes (typically >Ø200µm)	Uses smaller focal spot sizes (typically <150µm)
Laser power range 1kW – 6kW	Laser power range up to 3kW
Used lower beam quality (preferably top-hat beam)	Uses good beam quality (typically single mode)
Weld shape determined by beam shape	Independent control of weld depth and weld width
Shield gas is commonly used	Shield gas sometimes used
Use temporal pulse shaping to avoid cracking	Rapidly move beam to avoid cracking

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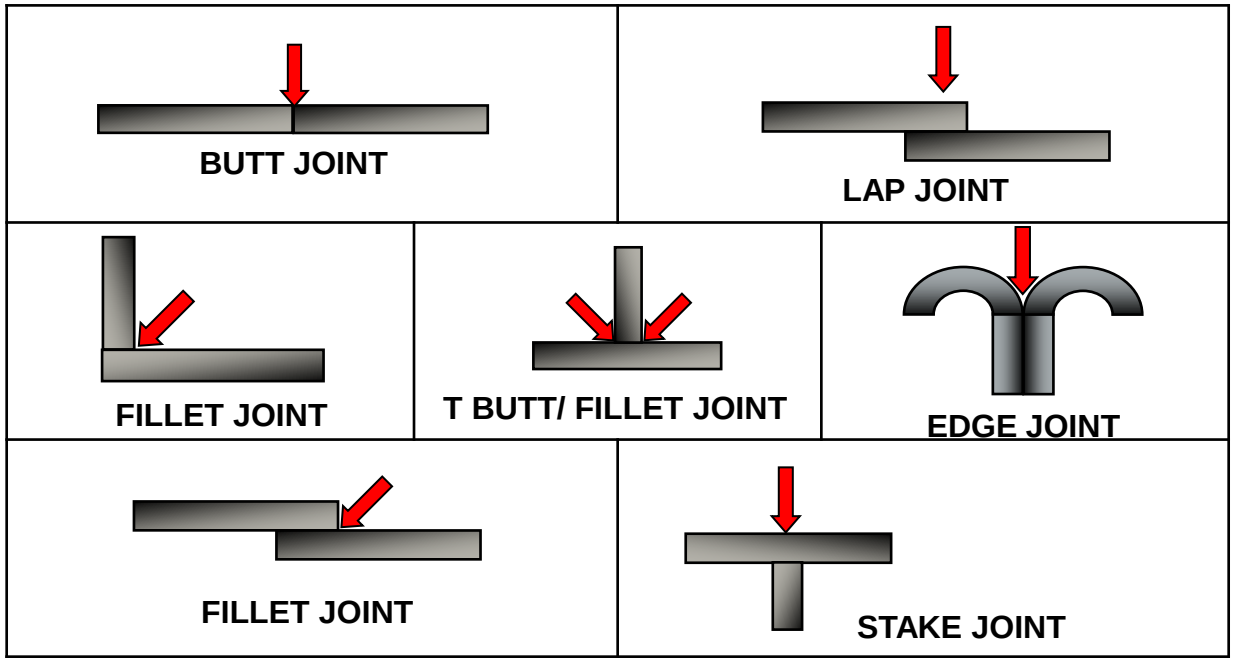
Weld Joint Configurations

- Oscillation Welding can achieve the same joint configurations as fixed-head welding.
- Oscillation is more tolerant of gaps and fit-up.



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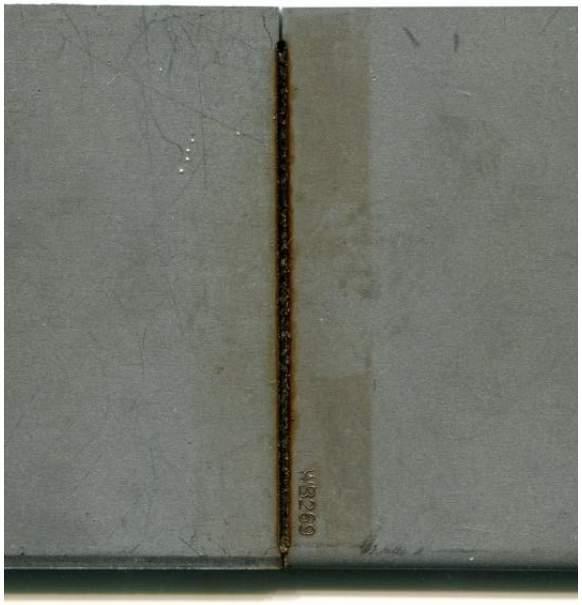
Advantages of Oscillation Welding

- Independent control of weld width and weld depth
- Able to process material grades which normally require filler wire (e.g. Aluminium 6000 series)
- More tolerant of gaps and fit-up issues
- Avoid the use of wire-feed
- Reduces hot-cracking



Example: 2mm SS butt weld.

Same result with 100µm gap between plates

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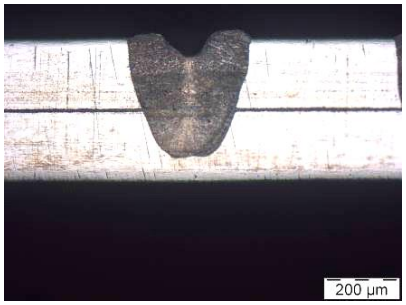
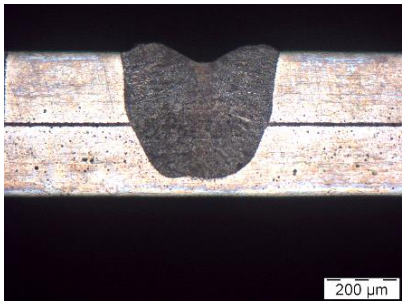
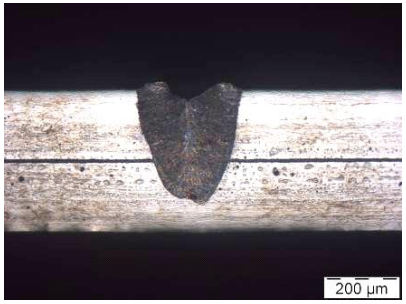
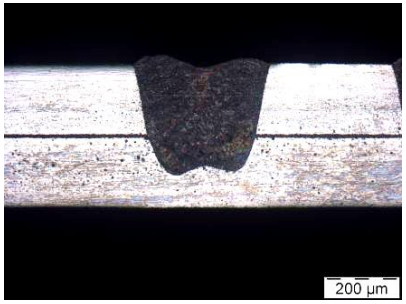
Weld Width Controllability

	D = 0,1 mm	D = 0,2 mm
V = 150 mm/s		
V = 250 mm/s		

Pictures courtesy of Fraunhofer ILT

- Good control over depth and width of the weld
- Weld width is mainly controlled by oscillation width

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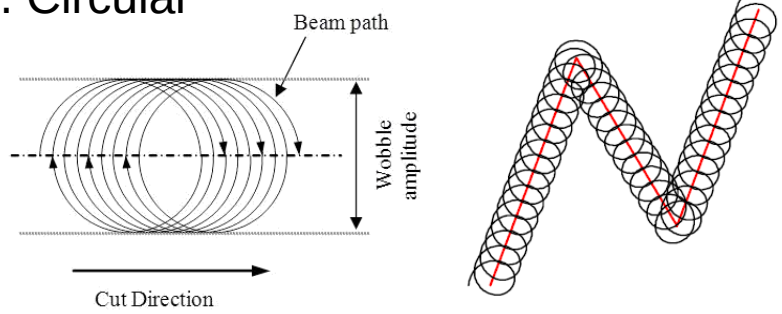
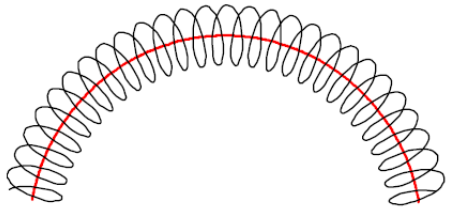
Weld Shapes

- Standard scanner control cards provide several different oscillation weld shapes:
- But oscillation needs to be fast, typically 1 to 3kHz.

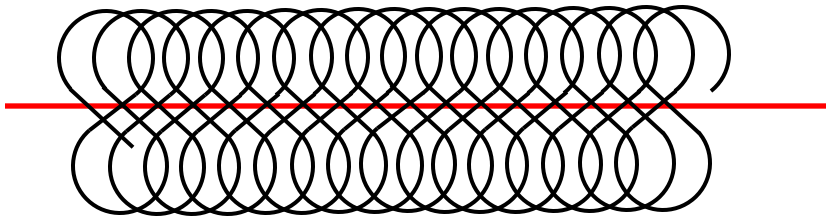
1. Circular



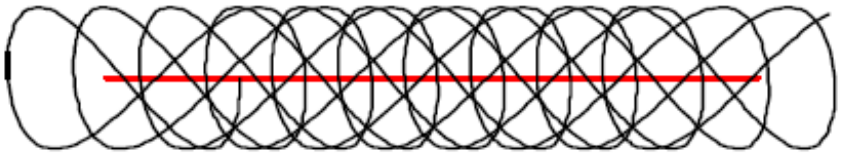
2. Ellipse



3. Figure of 8



4. Infinity



Figures courtesy of Scanlab GmbH

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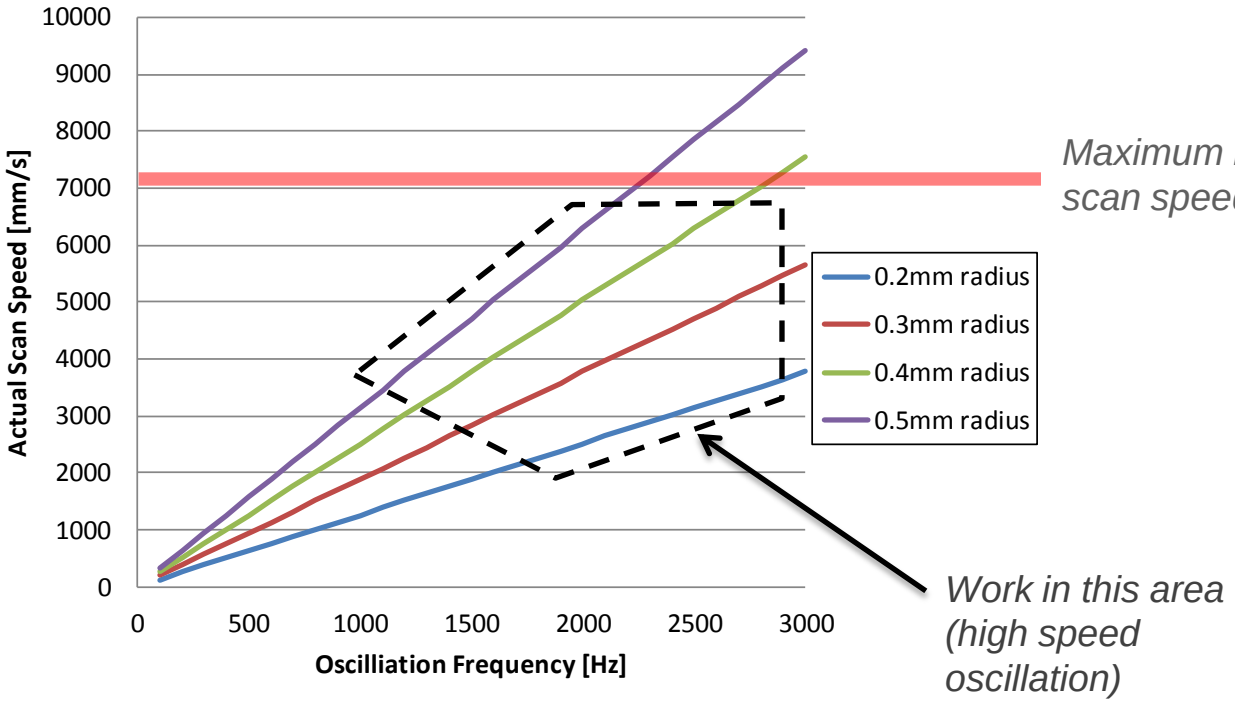
Oscillation Welding Parameters – Wobble Frequency

- As the frequency increases the actual speed of the beam rapidly increases
- For larger diameter oscillations, it's easy to reach the maximum scan speed (e.g. 0.5mm radius @ 3kHz = 9400 mm/s)



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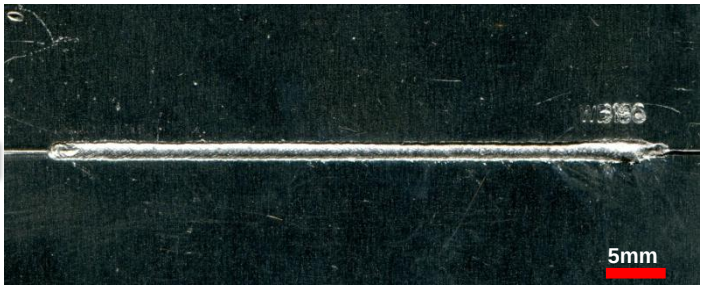
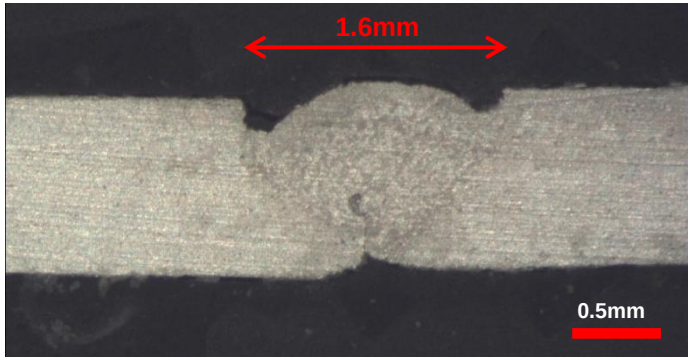
Aluminium Butt Weld - Example



TOPSIDE

- Butt weld 1mm Al
- Grade 5251 (Al Mg2)
- Power 1200W
- Speed 5.1 m/min
- 0.5mm wobble radius
- Oscillation frequency 2000Hz
- Top width of weld = 1.6mm
- No shield gas

BACKSIDE



SECTION

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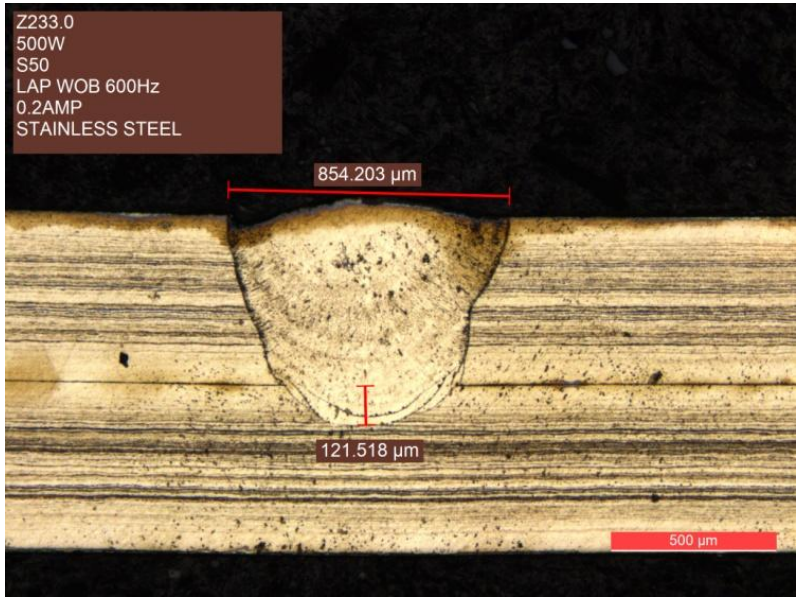
Stainless Steel Lap Welding - Example

- Using 500W SM laser
- Lap weld: 0.5mm to 0.5mm SS (grade 316)
- Weld width at top surface: 850µm
- Weld width at interface: 550µm
- Weld depth into lower material: 120µm
- Wobble radius 0.2mm
- Oscillation frequency 600Hz
- Weld speed: 3m/min



Minimise penetration into second material whilst maintaining weld strength.

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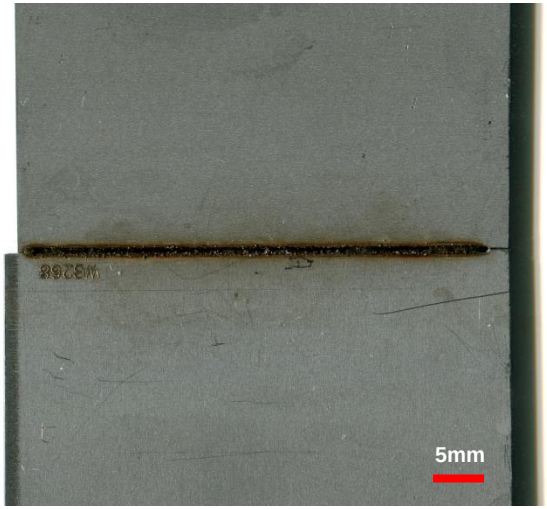
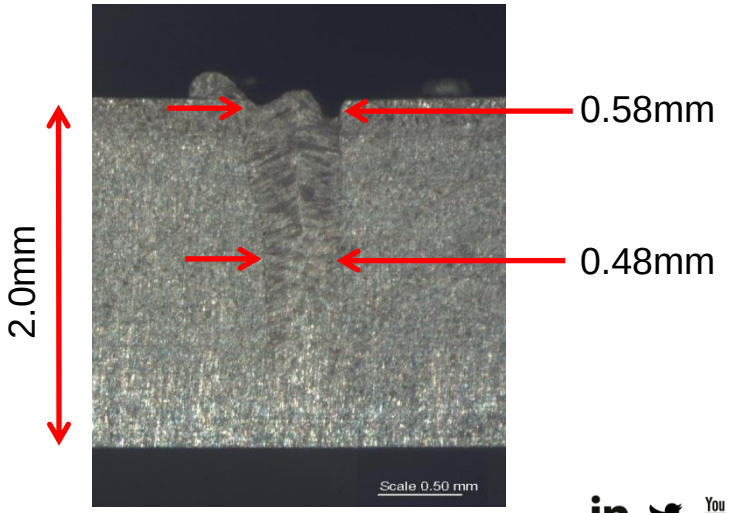
Stainless Steel Butt Weld

- 2mm thick SS
- Grade 316
- Laser power 1kW
- Weld speed 3m/min
- Weld width 0.48mm
- Wobble radius 0.2mm (circular)
- Oscillation frequency 1500Hz
- No gas shield
- Full penetration
- Tolerant to 100µm gap





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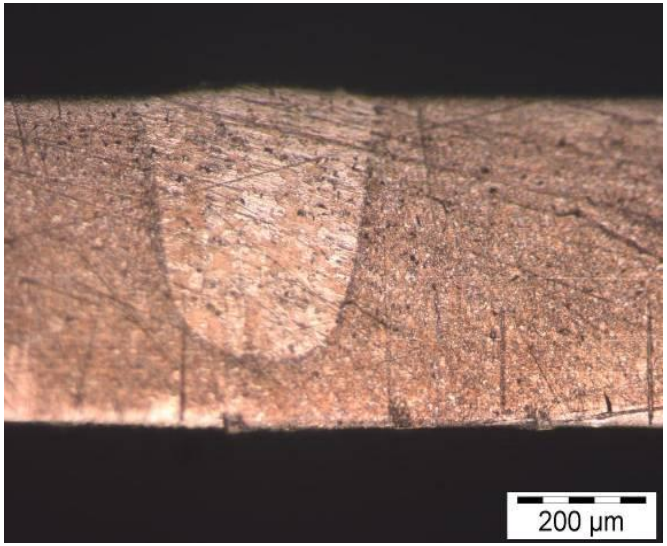
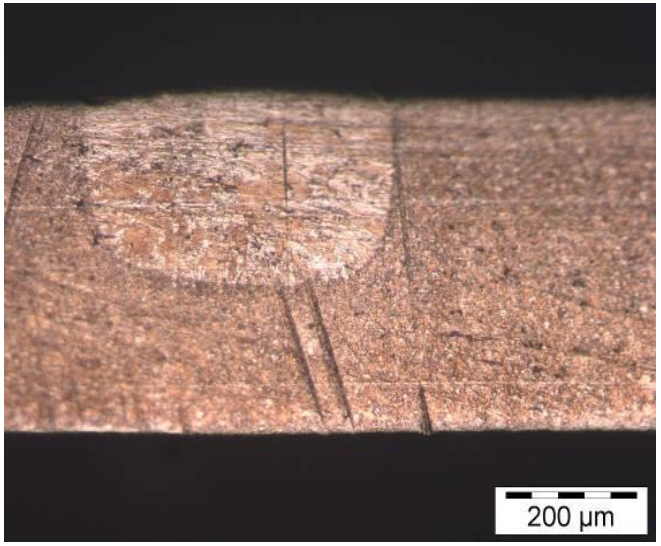
Copper Welding



0,1 mm amplitude



0,2 mm amplitude

Pictures courtesy of Fraunhofer ILT

- Copper (CuSn6)
- Laser power 200W
- Linear speed 30mm/s
- Excellent control over depth and width of the weld

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QUBE 2kW Cased Laser

- **Ideal for:**
  - Oscillation welding
  - Remote welding applications
  - High speed foil slitting
- **Class-leading 10m Single Mode delivery fiber (25µm, M2=1.2±0.1):**
  - Also 50um and 100um MM delivery fibers up to 20m long
- **High speed modulation capability:**
  - up to 50kHz
- **Back Reflection Protection**
  - inherent to PIPA-Q Fiber Termination design.
- **FiberView comprehensive control software:**
  - With integrated pulse shaping.

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Summary

- Oscillation welding uses a single mode high power laser with a scanner to rapidly move the laser beam in the weld pool.
- The weld depth and width can be controlled independently.
- Adjust scanner parameters to control weld shape.
- For best results oscillation frequency should be high.
- Oscillation welding is more tolerant to gaps and fit compared to fix head welding.

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